VII. CLAIMS

What is claimed is:

1. An acoustic transducer, comprising:

a substrate;

a micromachined membrane fabricated on said substrate;

a layer of material sealing said membrane to form a flexible diaphragm; and

electronics connected to said diaphragm.

2. The transducer of claim 1 wherein said micromachined membrane includes a serpentine shaped spring.

3. The transducer of claim 2 wherein said serpentine shaped spring is comprised of a plurality of alternately positioned long and short arms.

4. The transducer of claim 3 wherein a longest side of each of said long arms is less than approximately 50 microns in length.

5. The transducer of claim 3 wherein a maximum spacing between adjacent arms is approximately 3 microns.

6. The transducer of claim 1 wherein said micromachined member includes a plurality of cells, each cell comprised of a plurality of serpentine shaped springs.

7. The transducer of claim 1 wherein the substrate is selected from a group consisting of ceramic, glass, silicon, printed circuit board, and silicon-on-insulator semiconductor devices.

8. The transducer of claim 1 wherein said layer of material is selected from a group consisting of polymer sealants.

9. The transducer of claim 1 wherein the diaphragm is supported by the substrate such that changes in air pressure result in movement of the diaphragm, and wherein said electronics senses the movement of said diaphragm and converts said movement into electrical signals.

10. The transducer of claim 1 wherein the diaphragm is supported by the substrate such that said electronics applies an electrical signal to said diaphragm, and wherein said diaphragm converts said electrical signal into an acoustic wave.

11. The transducer of claim 1 wherein said electronics comprises an input circuit coupled to said diaphragm for actuating said diaphragm with an electrical input.

12. The transducer of claim 11 wherein said input circuit comprises:

a digital signal processor (DSP) having a first input terminal for receiving input digital audio signals, a second input terminal for receiving a digital feedback signal indicative of displacement of said diaphragm, and a first output terminal, and wherein said DSP provides at said first output terminal a digital difference signal from said input digital audio signals and said digital feedback signal; and

a pulse width modulator having an input terminal coupled to said first output terminal for receiving said difference signal, and an output terminal coupled to said diaphragm.

13. The transducer of claim 12 wherein said pulse width modulator converts the digital difference signal into a 1-bit pulse width modulated (PWM) signal, and wherein said pulse width modulator applies via its output terminal the 1-bit PWM signal to said diaphragm as an electrical input.

14. The transducer of claim 12 wherein said electronics further comprises a feedback circuit coupled to said DSP and said diaphragm, and wherein said feedback circuit generates said digital feedback signal.

15. The transducer of claim 14 wherein said input digital audio signals, said digital feedback signal, and said digital difference signal are pulse code modulated (PCM) signals.

16. The transducer of claim 14 wherein said feedback circuit includes a sense amplifier coupled to said diaphragm and an analog to digital converter coupled between said sense amplifier and said DSP.

17. The transducer of claim 16 wherein said sense amplifier includes a pressure sensor.

18. The transducer of claim 17 wherein said pressure sensor includes a CMOS MEMS microphone.

19. The transducer of claim 17 wherein said sense amplifier includes a position sensor.

20. The transducer of claim 16 further comprising a housing carrying the substrate and at least one of said DSP, said pulse width modulator, said sense amplifier and said analog to digital converter.

21. The transducer of claim 16 wherein at least one of said DSP, said pulse width modulator, said sense amplifier and said analog to digital converter is fabricated onto said substrate.

22. An acoustic transducer, comprising:

a substrate;

a micromachined membrane fabricated on said substrate;

a layer of material sealing said membrane to form a flexible diaphragm;

an input circuit for actuating said diaphragm; and

a feedback circuit coupled between said diaphragm and said input circuit.

23. The transducer of claim 22 wherein said substrate includes a backhole extending through said substrate and positioned under said flexible diaphragm.

24. The transducer of claim 22 wherein said input circuit includes a digital signal processor (DSP) and a circuit for applying an output of said DSP to said diaphragm.

25. The transducer of claim 24 wherein said DSP periodically outputs a test frequency to measure acoustic impedance, and wherein said DSP uses said measured acoustic impedance in the production of its output signal.

26. The transducer of claim 22 wherein said feedback circuit includes a sense amplifier coupled to said diaphragm and an analog to digital converter coupled between said sense amplifier and said input circuit.

27. The transducer of claim 26 wherein said sense amplifier includes a pressure sensor.

28. The transducer of claim 27 wherein said pressure sensor includes a CMOS MEMS microphone.

29. The transducer of claim 26 wherein said sense amplifier includes a position sensor.

30. The transducer of claim 22 further comprising a housing carrying the substrate and at least one of said input and said feedback circuits.

31. The transducer of claim 22 wherein at least one of said input circuit and said feedback circuit is fabricated on said substrate.

32. A method of fabricating a flexible diaphragm on a substrate, comprising:

forming a layer on a substrate;

forming a micromachined membrane from said layer; and

sealing said membrane.

33. The method of claim 32 wherein said step of forming a micromachined membrane includes the steps of etching said layer to form a serpentine spring and releasing portions of said spring from said substrate.

34. The method of claim 33 wherein said etching step includes the step of etching said layer to form a serpentine spring having a plurality of alternately positioned long and short arms.

35. The method of claim 34 wherein said etching step includes the step of etching said layer so that a longest side of each of said long arms is less than approximately 50 microns in length.

36. The method of claim 34 wherein said etching step includes the step of etching said layer so that a maximum spacing between adjacent arms is approximately 3 microns.

37. The method of claim 32 wherein said step of forming a micromachined membrane includes the steps of etching said layer to form a plurality of cells, each cell comprised of a plurality of serpentine spring shapes, and releasing portions of said spring shapes from said substrate.

38. The method of claim 37 wherein said step of releasing portions includes releasing certain of said spring shapes in their entireties.

39. The method of claim 32 wherein said step of sealing said membrane includes depositing one of a layer of sealant and a layer of laminating film.

40. The method of claim 39 including the step of etching the deposited layer to achieve a desired thickness.

41. A method of fabricating a transducer, comprising:

fabricating electronics on a substrate using CMOS processes;

forming a layer on a substrate;

forming a micromachined membrane from said layer; and

sealing said membrane to form a diaphragm, said diaphragm being in communication with said electronics.

42. The method of claim 41 wherein said step of forming a micromachined membrane includes the steps of etching said layer to form a serpentine spring and releasing portions of said spring from said substrate.

43. The method of claim 42 wherein said etching step includes the step of etching said layer to form a serpentine spring having a plurality of alternately positioned long and short arms.

44. The method of claim 43 wherein said etching step includes the step of etching said layer so that a longest side of each of said long arms is less than approximately 50 microns in length.

45. The method of claim 43 wherein said etching step includes the step of etching said layer so that a maximum spacing between adjacent arms is approximately 3 microns.

46. The method of claim 41 wherein said step of forming a micromachined membrane includes the steps of etching said layer to form a plurality of cells, each cell comprised of a plurality of serpentine spring shapes, and releasing portions of said spring shapes from said substrate.

47. The method of claim 46 wherein said step of releasing portions includes releasing certain of said spring shapes in their entireties.

48. The method of claim 41 wherein said step of sealing said membrane includes depositing one of a layer of sealant and a layer of laminating film.

49. The method of claim 48 including the step of etching the deposited layer to achieve a desired thickness.

50. The method of claim 41 additionally comprising the step of enclosing said transducer in a housing.

51. A method of audio reproduction, comprising:

electrostatically biasing a MEMS diaphragm, said diaphragm fabricated on a supporting substrate in a first plane; and

providing an electrical audio input signal to said diaphragm to cause said diaphragm to move in a direction perpendicular to said first plane.

52. The method of claim 51 additionally comprising:

measuring the displacement of the diaphragm to produce a feedback signal;

modifying the electrical audio input signal with said feedback signal.

53. The method claim 51 additionally comprising:

periodically measuring an acoustic impedance; and

modifying the electrical audio input signal in response to said measured acoustic impedance.